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INFLUENCE OF CROP LOAD ON SUGARS AND PECTIN CONTENT OF GUAVA (*PSIDIUM GUAJAVA* L.) cv. ALLAHABAD SAFEDA AT DIFFERENT STAGES OF FRUIT GROWTH UNDER MEADOW PLANTING SYSTEM

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Abstract

The aim of the present study was to find out the effect of fruit thinning on sugars and pectin content of guava (*Psidium guajava* L.) cv. Allahabad Safedaat different stages of fruit growth under meadow planting system. The study was carried out at the Fruit Research Station, Sangareddy, Sri Konda Laxman Telangana State Horticultural University, Hyderabad during the period of October, 2016 to February, 2017 (Hasta bahar crop). The experiment was laid out in randomized block design with factorial concept. The treatments of the experiment were crop load levels *i.e*. retaining of 5, 10, 15, 20 fruits per plant and control (No thinning) and second factor taken as a observation recorded after fruit thinning i.e. (i) 30 days after fruit set (ii) 60 days after fruit set (iii) 90 days after fruit set and at the time of harvest. The ages of the plants were 4-5 years. A gradual increase of sugars and pectin from 30 days after fruit set to harvest of fruits.The pectin content increased up to 90 days and there after it declined rapidly and increased from 0.84% to 1.20% from 30 to 90 days. Afterwords the pectin content was shown decreased level at the time of harvest (0.95%). Total sugars (2.10 to 8.71%), reducing sugars (0.74% to 2.42%) and non-reducing sugars (1.30% to 5.95%) content was shown increased trend during fruits growth and development. Total sugars and reducing sugars showed significant resultswith 5 fruits per plant at the time of harvest as compared to control.

Key words : Hasta bahar, pectin, thinning and crop load.

Introduction

Guava (*Psidium guajava* L.) is one of the most popular fruit grown in tropical and subtropical regions of India, which belongs to the family Myrtaceae. The genus Psidium comprises about 150 species of small shrubs and trees (Hayes, 1970). About 20 species have edible fruits of which the most commonly cultivated is the common guava (*Psidium guajava* L). It is native to tropical America which was introduced in India (Mitraand Bose, 2001) in the 17th century by Portuguese (Menzel, 1985). It stands fourth most important fruit crop in both area and production after mango, bananaandcitrus. At present in India, it occupies nearly 2,68,000 ha area with a production of 36.67 lakh tonnes and productivity 13.7 MT ha^{-1} (NHB, 2014). Though, it is successfully grown all over the country, the important guava growing states are Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, Punjab, Gujarat Karnataka, Andhra Pradesh and Telangana. It is majorly grown in Rangareddy, Khammam, and Medak districts of Telangana state with an area of 6000 ha and 90,000 tonnes of production with productivity of 15 MT ha^{-1} (NHB, 2014). It is most preferred for arid and semiarid fruit production in India.

Guava is rich source of vitamin C and it contains three to fourtimes more vitamin C as compared to fresh orange juice, alongwith the minerals namely iron, calcium, and phosphorus. It isused for preparation of jam and jelly due to its high pectincontent. Ripe fruits are also used for

manufacturing of icecream, sherbet, cheese, candy, puree and toffee. Leaves aresource of dye and tannin and have medicinal value, being used for curing diarrhoea. However, guava is guaranteedsource of ascorbic acid, pectin, sugars, etc. which play therole in processing. Hence, it is need to process guava on alarge scale by using either red or white fleshed guava. The processed red fleshed guava might be novelty in guava industry. The extent of variability in guava for vegetative and fruit characteristics has been estimated by several workers (Deshmukh *et al*., 2013; Rattanpal and Dhaliwal, 1999; Thimmappaiah *et al*., 1985). Fruit thinning is defined as the removal of certain flowers or clusters of flowers or individual fruitlets after fruit set and natural dropping have occurred. It improves fruit yield and quality and return bloom for the following year, so it is an essential operation to do in fruit crops.

Various experiments have been conducted earlier on crop load and thinning of flowers and fruits in different fruit crops for better quality of fruits. Therefore, based on the possible benefits, the present work is done to study the effect of crop load, fruit thinning and their effects on quality attributes like sugars and pectin content of guava (*Psidium guajava* L.) cv. Allahabad Safeda under meadow planting system.

Materials and Methods

The experiment was carried out during the period of October, 2016 to February, 2017 (Hasta bahar crop) at Fruit Research Station (FRS), Sangareddy, SKLTSHU, Telangana, India. Fruit Research Station was situated at an altitude of 1743 feet above mean sea level on 17° 37.300' North latitude and 78° 04.601'18 East longitude. The experiment was laid out in randomized block design with factorial concept with 20 treatments in 3 replications. The fruits were tagged in four directions of plant during the thinning time as per the treatments and replicated three times; plants are of 4-5 years old and planted in 2×1m spacing. The data was recorded at monthly intervals from fruit set to harvest to observe quality parameters like sugars and pectin with levels of crop load effects. The treatments of the experiment were crop load levels *i.e.* retaining of 5, 10, 15, 20 fruits per plant and control (No thinning) and second factor as a observations recorded after fruit thinning *i.e.* (i) 30 days after fruit set (ii) 60 days after fruit set (iii) 90 days after fruit set and at the time of harvest.In these treatments, total number of fruits per plant in each replication was counted after fruit set. Out of these 5, 10, 15, 20 fruits per plant of fruits were retained and in control *i.e.* there is no thinning and remaining fruits were thinned randomly by manual thinning and the second factor is considered as a treatment for knowing of crop load effects at different stages of fruit growth.

Biochemical parameters

Reducing sugars

Sugars are members of the carbohydrate family. Examples include glucose, fructose and sucrose. Some sugars can act as reducing agents and these sugarswill contain an aldehyde functional group. This property can be used as a basisfor the analysis of reducing sugars. For example Fehling's solution containscopper (II) ions that can be reduced by some sugars to copper (I) ions. This reaction can be used for the quantitative analysis of reducing sugars. Invert sugar reduces the copper in Fehling's solution to red, insoluble cuprous oxide. The sugar content in a fruit sample is estimated by determining the volume of the unknown sugar solution required to completely reduce a known volume of Fehling's solution. Glucose and other sugars are capable of reducing oxidizing agents and are called reducing sugars and this property is used for the estimation of sugars. The cupric ion in Fehling's solution is reduced to cuprous state which precipitates as red cuprous oxide (Cu_2O). Only reducing sugars reduce the copper solution. The method is suitable for estimation of sugars in fruit.

The reducing sugar content was estimated by Nelson's Somogyi method (Nelson, 1944). The preparation of working standard (10 to100µg) and made up to volume to 1 ml with distilled water in all tubes, maintained a reagent blank with 1ml distilled water and added 1ml of alkaline copper reagent to all the tubes and placed in boiling water bath for 20 minutes, allowed to cool and add 1ml of arsenomolybdate reagent and made up the volume to 20ml. With distilled water and read the absorbance of standard and the sample against reagent blank, which was set to 100 per cent absorbance at 540 nm in an spectrophotometer.

$$\text{Factor for Fehling solution (g of invert sugar)} = \frac{\text{Titre} \times 2.5}{1000}$$

$$\% \text{ Reducing Sugar} = \frac{\text{Factor for Fehling solution} \times \text{Volume made} \times 100}{\text{Titre} \times \text{wt. of sample} \times \text{ml of aliquot}}$$

Total sugars (%)

Total sugars were also determined by Lane and Eynon method (Ranganna, 1986). A quantity of 50ml lead free filtrate was taken in a 100ml volumetric flask and 5ml of concentrated HCl was added to it, mixed well and kept for 24 hours at room temperature. Acid was then neutralized with NaOH using a drop of phenolphthalein

as an indicator till the pink colour persisted for at least few seconds. Then volume was made up to 100ml. Total sugars were then estimated by taking this solution into a burette and titrating it against standard Fehling's solution mixture of A and B (1:1) using methylene blue as an indicator to a brick red colour as an end point. The results were calculated and expressed as percent total sugars with the following formula. (10ml Fehling's solution = 0.052g glucose).

$$\text{Total sugars (\%)} = \frac{\text{Factor} \times \text{Dilution 1} \times \text{Dilution 2} \times 100}{\text{Titre} \times \text{Wt. of sample} \times \text{Aliquot taken}}$$

Non-reducing sugar (%)

The percentage of non-reducing sugars was obtained by subtracting the percentage of reducing sugars from the total sugars and expressed in percentage.

Non-reducing sugars (%) = Total sugars – Reducing sugar.

Pectin (%)

Total pectin as calcium pectate in fresh fruits was estimated by the methods of Ranganna (1979). For estimation of pectin, 25 g of fresh fruit macerated samples were taken in a flask. To this, 200 ml distilled water was added and kept on hot plate for one hour. The water lost during boiling was replaced simultaneously. The flask was then cooled and volume was made up to 250 ml. the contents of flask were then filtered through Whatman filter paper no. 4.To 50 ml portion of the filtrate, 50 ml of distilled water and 5 ml of 1 N NaOH was added and kept overnight. Next day, 25 ml of acetic acid solution was added and after 5 minutes, 12.5 ml of 1N calcium chloride solution was added with string. After allowing it to stand for one hour, it was boiled for one minute and filtered through oven dried, previously weighed Whatman filter paper no. 4. The precipitates were then dried at 100°C overnight, cooled in desiccators and weighed. The amount of pectin was expressed as per cent calcium pectate.

$$\text{Calcium pectate (\%)} \frac{\text{Weight of calcium pectate} \times \text{Volume of content}}{\text{Volume of filtrate} \times \text{Weight of sample for estimation}} \times 100$$

Results and Discussion

Reducing sugars (%)

Data presented in table 1 showed an increasing trend for reducing sugar content in fruit pulp till last harvesting in guava cv. Allahabad Safeda. Reducing sugar recorded highest at the time of harvest (2.45%), which may be due to conversion of non-reducing sugar, which may be attributed to the hydrolysis of starch into simple sugars and also by continues mobilization of sucrose from leaves to the fruit. At initial stages of growth the lowest reducing sugar was noticed at 30 days after fruit set (0.74%) and continuous development on 60 days after fruit set (0.82%) and 90 days after fruit set (1.48%). The increase in sugars may be due to the conversion of starch into sugars. Since, the carbohydrates are manufactured in the leaves and then translocate to the fruits, this regular increase in sugars in pulp of fruits was mainly due to the augmented translocation of photosynthates from leaves to fruits (Dhilley, 1970; Biale, 1975). Reducing sugars showed increasing trend during late maturity in guava. Climacteric fruits, in particular, may show considerable changes in sugar content during fruit ripening. Results are in close consonance with various researchers as Nag *et al*. (2011), Jain *et al*. (2001), WafaaAly (2013) and Patel *et al*. (2013) in guava varieties. Significant difference was noted in relation to fruit load, the highest reducing sugar was observed in 5 fruits per plant (1.43%) and followed by 10 fruits per plant (1.40%), which was on par with 15 fruits per plant (1.39%) and lowest was observed in control (1.30%). Improvement in reducing sugars and non-reducing sugars might be attributed due to reduced crop load due to thinning of young fruitlets, which resulted in more synthesis, transport and accumulation of sugars in the remaining fruits. The results are in close conformity with Casierra *et al*. (2007). The maximum reducing sugar noticed at the time of harvest with 5 fruits per plant (2.51%) and minimum was noticed in control (no thinning) *i.e.* (0.72%) at 30 days after fruit set.

Total sugars (%)

The data pertaining to the total sugars content was presented in the table 2, which indicates that there was a significant change in total sugars among the treatments (30, 60, 90 days after fruit set and at the time of harvest). Total sugar content showed a continuous increase (fig. 2) from initial stages of fruit development till up to harvest. Total sugars increased with fruit growth at initial stages of growth *i.e.* 30 days after fruit set having (2.10%) and it continuous to 60 days after fruit set (3.46%), 90 days after fruit set (4.77%) and at the time of harvest shown higher percentage (8.71%) of total sugars. This trend could be due to hydrolysis of starch during ripening resulting in accumulation of sucrose (Pantastico *et al*., 1975). The observations are in close proximity to the findings of Dhua *et al*. (2006), who studied the chemical changes of developing fruit and reported that the total sugar contents in general increased during fruit development but

Table 1: Effect of crop load on reducing sugars (%) at 30, 60, 90 days and at the time of harvest in guava cv. Allahabad Safeda under meadow planting system.

Treatments	Days after fruit set (DAFS)				
Crop load	**30**	**60**	**90**	**At harvest**	**Mean**
5 fruits per plant	0.77	0.85	1.58	2.51	1.43^{d}
10 fruits per plant	0.76	0.84	1.54	2.47	1.40^{c}
15 fruits per plant	0.75	0.83	1.52	2.47	1.39^{c}
20 fruits per plant	0.73	0.81	1.48	2.43	1.36^{b}
Control	0.72	0.79	1.28	2.40	1.21^{a}
Mean	0.74^{A}	0.82^{B}	1.48^{C}	2.45^{D}	
	DAFS(A)	**CL (B)**	**A × B**		
CD at 5%	0.012	0.014	0.027		
SE (m) ±	0.004	0.005	0.009		

Table 2 : Effect of crop load on total sugars (%) at 30, 60, 90 days after fruit set and at the time of harvest in guava cv. Allahabad Safeda under meadow planting system.

Treatments	Days after fruit set(DAFS)				
Crop load	**30**	**60**	**90**	**At harvest**	Mean
5 fruits per plant	2.16	3.55	4.87	8.82	4.85^{b}
10 fruits per plant	2.10	3.53	4.86	8.76	4.81^{b}
15 fruits per plant	2.12	3.51	4.80	8.71	4.78^{b}
20 fruits per plant	2.06	3.47	4.75	8.66	4.73^{a}
Control	2.09	3.27	4.55	8.58	4.62^{a}
Mean	2.10^{A}	3.46^{B}	4.77^{C}	8.71^{D}	
	DAFS(A)	**CL (B)**	**A × B**		
CD at 5%	0.109	0.121	NS		
SE (m) ±	0.038	0.042	0.084		

Table 3 : Effect of crop load on non-reducing sugars (%) after fruit set at (30, 60, 90 days and at the time of harvest) in guava cv. Allahabad Safeda under meadow planting system.

Treatments	Days after fruit set (DAFS)				
Crop load	**30**	**60**	**90**	**At harvest**	Mean
5 fruits per plant	1.33	2.57	3.13	6.01	3.26
10 fruits per plant	1.28	2.56	3.17	5.98	3.25
15 fruits per plant	1.30	2.55	3.12	5.94	3.23
20 fruits per plant	1.27	2.54	3.12	5.92	3.21
Control	1.31	2.36	3.11	5.88	3.16
Mean	1.30A	2.51B	3.13C	5.95D	
	DAFS(A)	**CL (B)**	**A × B**		
CD at 5%	0.104	NS	NS		
SE (m) ±	0.036	0.040	0.081		

accumulation of sugars was less during first 120-150 days after fruit set but increased rapidly thereafter. There was a gradually increase of total sugars in sapota fruits till maturity. These results are in with Ingle *et al*. (1982), Bandhopadhyaya and Sen (1998) and Brito and Narian (2002) and in sapota. Results are in accordance to findings obtained by Mitra and Bose (1996), El-Bulk *et al*. (1997), Mercado- Silva *et al.*(1998), Selvaraj *et al*. (1999), Bashir *et al*. (2003), Hegde and Chharia (2004) and Singh and Jain (2007). Significant difference was noted in relation to fruit load. The highest total sugars was recorded with 5 fruits per plant (4.85%), which is on par with 10 fruits

Table 4 : Effect of crop load on pectin (%) at 30, 60, 90 days after fruit set and at the time of harvest in guava cv. Allahabad Safeda under meadow planting system.

Treatments	Days after fruit set (DAFS)				
Crop load	**30**	**60**	**90**	**At harvest**	**Mean**
5 fruits per plant	0.85	0.92	1.13	0.92	0.95
10 fruits per plant	0.81	0.90	1.13	0.95	0.95
15 fruits per plant	0.84	0.95	1.18	1.05	1.01
20 fruits per plant	0.82	0.92	1.25	0.90	0.97
Control	0.90	0.96	1.32	0.92	1.02
Mean	0.84[a]	0.93[b]	1.20[d]	0.95[c]	
	DAFS (A)	**CL (B)**	**A × B**		
CD at 5%	0.091	NS	NS		
SE (m) ±	0.032	0.035	0.071		

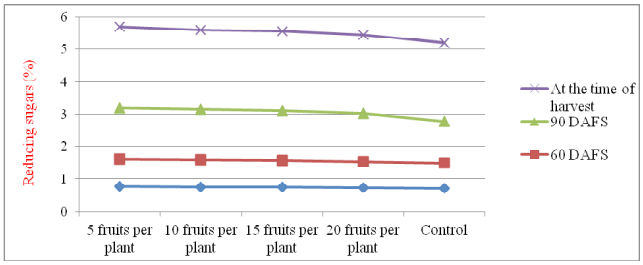

Fig. 1 : Effect of crop load on reducing sugars (%) at 30, 60, 90 days and at the time of harvest in guava cv. Allahabad Safeda under meadow planting system.

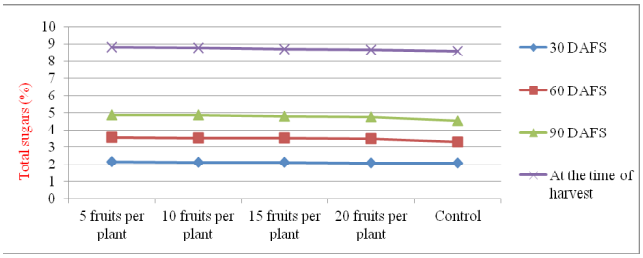

Fig. 2 : Effect of crop load on total sugars (%) at 30, 60, 90 days after fruit set and at the time of harvest in guava cv. Allahabad Safeda under meadow planting system.

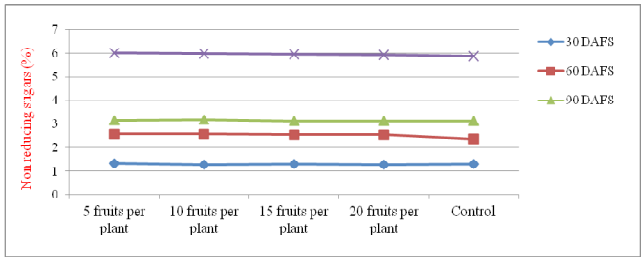

Fig. 3 : Effect of crop load on non-reducing sugars (%) at 30, 60, 90 day after fruit set and at the time of harvest in guava cv. Allahabad Safeda under meadow planting system.

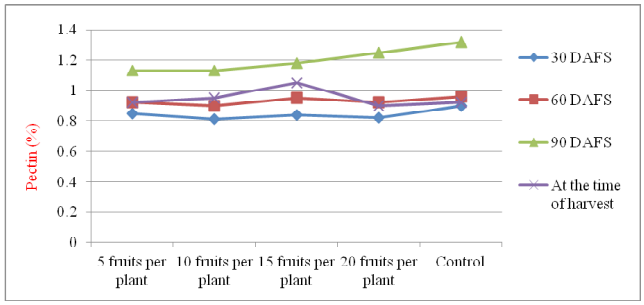

Fig. 4 : Effect of crop load on pectin (%) at 30, 60, 90 days after fruit set and at the time of harvest in guava cv. Allahabad Safeda under meadow planting system.

per plant (4.81%), 15 fruits per plant (4.78%) and lowest total sugars noticed in control (4.62%), which was on par with 20 fruits per plant (4.73%) showed in table 2. Soliman *et al*. (2011) reported that thinning 30% of the total number of strands significantly increased total sugars percent than the control and thinning 15% treatment in date palm. The interaction between days after fruit set and crop load was found to be non-significant on total sugar in guava cv. Allahabad Safeda.

Non reducing sugars (%)

A perusal of data presented in the table 3 reveals that non-reducing sugars (%) differed significantly among the treatments. During various stages of growth and development of fruits, observed that non-reducing sugars increased with fruit growth at initial stages of growth i.e. 30 days after fruit set having (1.30%) and it continuous to 60 days after fruit set (2.51%), 90 days after fruit set (3.13%) and at the time of harvest shown higher percentage (5.95%) of non-reducing sugars. The non-reducing sugars gradually increased till maturity. At full maturity the non-reducing sugars were 7.21 per cent in sapota (Dhanashree *et al*., 2010). The non-reducing sugars of the ber fruit increased continuously from fruit set till maturity but the differences were non-significant at 15 days, 30 to 45 and 90 to 105 days after fruit set (Pandey *et al*., 1990). Further similar reports were made by Bandhopadhyaya and Sen (1998), Khodade *et al*. (1990)

in pomegranate and Harding *et al*. (1954) in mango. There was no significant variation was observed in relation to fruit load. The interaction between days after fruit set and crop load was found to be non-significant on non-reducing sugar in guava cv. Allahabad Safeda.

Pectin (%)

Pectin content showed significant variation in the guava cv. Allahabad Safeda during investigation. The pectin content increased up to 90 days there after it declined rapidly. Pectin content increased from 0.84% to 1.20% from 30 to 90 days showed in fig. 4. Afterwords the pectin content was shown decreased level at the time of harvest (0.95%). Similar finding in guava cultivars at various locations were also reported by El-Bulk *et al.* (1997), Selvaraj *et al*. (1999). Pectin degradation is linked with ascorbic acid production and it is postulated that glacturonic acids are substrates needed in synthesis of ascorbic acid. Period of ascorbic acid accumulation corresponded with falling of pectin content in fruit (Yan *et al*., 2006). Increase in pectin content during fruit development might be due to conversion of other forms of pectin into water soluble form of pectin and in later stage the decrease in pectin could be due to enzymatic degradation of pectin with advanced ripening (Paul and Chen, 1983). During ripening of fruits, the softening has been interpreted as the solubilisation of pectic substances from the middle lamella and hence an associated rise in soluble pectin. Similar results regarding pectin content was also supported by Hegde and Chharia (2004), Suryakanth and Mukunda (2007). There was no significant variation was observed in relation to fruit load. The interaction between days after fruit set and crop load was found to be non-significant on pectin content in guava cv. Allahabad Safeda.

Conclusion

During various stages of growth and development of fruits *i.e.* 30, 60, 90 days after fruit set and at the time of harvest, observed that total sugars, reducing sugars and pectin content increased with fruit growth. From the results, it can be concluded that, guava is one of the natural sources of food grade pectin, which finds uses in various food product formulations as a thickening and gelling agent. Fruit thinning on heavy loaded natural crop is an efficient method to improve quality of fruits. Hence, there is a scope for distribution of crop load in two seasons instead of one season will reduce stress on the plants and income of farmers can also be increased due to availability of quality fruits in mrigbahar and hasta bahar.

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